ACCESSION #: 9610230164

LICENSEE EVENT REPORT (LER)

FACILITY NAME: Browns Ferry Nuclear Plant (BFN) Unit 3 PAGE: 1 OF 6

DOCKET NUMBER: 05000296

TITLE: Reactor Scram Required by Technical Specifications Due To

Trip of Reactor Recirculation Motor Generator Set 3A

EVENT DATE: 9/15/96 LER #: 96-005-00 REPORT DATE: 10/15/96

OTHER FACILITIES INVOLVED: DOCKET NO: 05000

OPERATING MODE: N POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:

50.73(a)(2)(i)

LICENSEE CONTACT FOR THIS LER:

NAME: B.C. Morris, Licensing Project TELEPHONE: (205) 729-7909

Manager

COMPONENT FAILURE DESCRIPTION:

CAUSE: X SYSTEM: AD COMPONENT: MG MANUFACTURER: G080

REPORTABLE NPRDS: Y

SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On September 14, 1996, at 2047 hours, Reactor Recirculation Motor Generator (MG) Set 3A tripped on loss of generator field. This resulted in tripping Reactor Recirculation Pump 3A. Power operation continued at a reduced level in single recirculation pump mode with Reactor Recirculation Pump 3B in service. BFN Technical Specifications (TS) require that the reactor be placed in hot shutdown within 24 hours if operating with only one recirculation loop. Therefore, reactor power was subsequently reduced to approximately 40 percent and the reactor manually scrammed at 1724 hours on

September 15, 1996. This event is being reported in accordance with 10 CFR 50.73 (a) (2) (ii) (A) as a completion of a plant shutdown required by TS.

Inspection of the MG set showed a bus bar in the generator armature circuit had failed. The companion bus bar was severely cracked in the same corresponding area and metallurgical tests determined high cycle fatigue was the failure mechanism. Both bus bars showed a pronounced bend inward toward the rotational axis. It is believed these bends, in conjunction with the rotational dynamics of the assembly, was the cause of the high cycle fatigue. It is likely the failed bus bar was similarly affected and high cycle fatigue over a long period of time ultimately led to electrical failure of the bus bar. Pronounced bends were not observed on the five remaining recirculation system MG set bus bar pairs on the Unit 1 and 2 MG sets, and MG Set 3B. Since none of the other MG set bus bars were found to be significantly bent, these MG sets are not considered susceptible to a similar failure. The exact cause of the large bends in the MG Set 3A bus bars could not be determined though the condition may have been caused by improper rigging during a past lift of the generator rotor assembly.

The MG Set 3A bus bars and generator collector rings were replaced, and the MG set and Reactor Recirculation returned to service on September 17, 1996.

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I. PLANT CONDITIONS

Prior to the Reactor Recirculation Pump 3A trip, Unit 3 was at 100

percent power. Unit 2 was at also at 100 percent power. Unit 1 was

shutdown and defueled.

II. DESCRIPTION OF EVENT

A. Event

On September 14, 1996, at 2047 hours, Reactor Recirculation

Motor Generator (MG)[MG] Set 3A tripped on loss of generator

field. This caused the loss of Reactor Recirculation Pump [AD]

3A. Following the trip, Unit 3 continued to operate at a

reduced power level in single recirculation pump mode with

Reactor Recirculation Pump 3B in service. BFN Technical

Specifications require that the reactor be placed in hot shutdown within 24 hours if operating with only one recirculation loop. Diagnosis of the cause of the trip and repair of the MG set could not be completed within this time frame. Therefore, power was reduced to approximately 40 percent power and the reactor manually scrammed at 1724 hours on September 15, 1996. Scram recovery was uneventful and reactor systems responded as expected.

This event is reportable in accordance with 10 CFR 50.73 (a)(2)(i)(A) as a completion of a plant shutdown required by plant TS.

B. Inoperable Structures, Components, or Systems that Contributed to the Event:

None.

C. Dates and Approximate Times of Major Occurrences:

September 14, 1996 - Central Standard Time

at 2046 hours - Recirculation MG Set 3A field ground alarm received in Unit 3 control room.

at 2047 hours - Recirculation Pump MG 3A Set tripped on loss of generator field. Loss of the MG set caused trip of Reactor Recirculation Pump 3A. Core power decreased due to resultant reduction in recirculation flow.

September 15, 1996

at 1724 hours - Unit 3 was manually scrammed from

approximately 40 percent power.

at 1820 hours - TVA made a 1-hour notification to NRC in

accordance with 10 CFR 50.72(b)(1)(i)(A)

for the initiation of plant shutdown

required by TS.

D. Other Systems or Secondary Functions Affected:

None.

E. Method of Discovery:

The Unit 3 Operator [utility, licensed) received a

Recirculation MG Set 3A field ground alarm followed by an MG

set generator lockout alarm in the Unit 3 Main Control Room.

F. Operator Actions:

Operations personnel [utility, licensed and nonlicensed]

responded to the loss of Reactor Recirculation Pump 3A

according to applicable operating procedures. Recirculation

flow was increased on Recirculation Pump 3B to exit the "region

of increased awareness" for thermal hydraulic instability on

the power/flow operating map per the abnormal operating

instruction for recirculation pump trips. No abnormal power

oscillations were observed.

Personnel were promptly dispatched to physically inspect the tripped MG set. Operators tagged the electrical power supplies to the MG Set as a precautionary measure pending a detailed diagnosis of the trip.

The subsequent manual shutdown of Unit 3 on September 15, 1996, proceeded in an orderly manner using applicable scram recovery procedures.

G. Safety System Responses:

All safety systems responded as designed for this type of event.

III. CAUSE OF THE EVENT

A. Immediate Cause:

The immediate cause of the recirculation MG set trip was the failure of a bus bar in the generator armature circuit.

B. Root Cause:

The generator slip ring to armature winding connection for the reactor recirculation pump MG sets is in the form of two

insulated bus bar assemblies (cylindrical copper rods approximately 5/8 inches in diameter) which make the connections. The bus bars are in two segments and are joined by brazing together flattened tabs on each bar segment. The armature unit including the bus bars is a rotating assembly

during MG set operation. At full recirculation pump flow, the speed of an MG set is approximately 1000 revolutions per minute.

Field inspection of MG Set 3A showed that one of the bus bars had a two inch long bar section missing in the area of the brazed joint. Physical evidence indicated the bar section had been melted by electrical current. The companion bus bar on MG Set 3A was inspected and the copper rod was deeply cracked in the area corresponding to the melted area of the failed bar. Only a 20-30 percent cross sectional area of the conductor rod was intact at the crack. Subsequent metallurgical testing of the cracked bar determined high cycle fatigue as the failure mechanism. A pronounced bend inward toward the rotational axis of the assembly was observed on both MG Set 3A bus bars. Similar large bends were not observed on the other five recirculation system MG sets (Units 1 and 2 MG Sets A and B, and MG Set 3B).

After considering the physical evidence and test results, the most probable explanation for the failure is as follows. Vibrational movement of the bar in response to the rotating assembly caused high cycle fatigue. The anomalous configuration of the bars due to the observed bends is the most significant factor leading to changes or increases in

vibrational movement. High cycle fatigue propagated a crack in each bar over a long period of time gradually reducing conductor cross sectional area. This ultimately led to complete failure when one of the bars was no longer capable of carrying full circuit amperage. The armature circuit is a high amperage circuit. This failure mechanism is considered a long term phenomenon although the final failure (melting of bar) would occur abruptly when the conductor capacity was reduced below its physical capability to carry full circuit amperage. There would be no observable effects on the performance of the MG set prior to a complete loss of bus bar continuity.

The cause of the bends could not be positively determined. As noted above, none of the remaining 5 MG set units were observed to have similar pronounced bends. A probable explanation would be that the bars were bent by improper rigging during a past generator rotor lifting operation in support of maintenance or refurbishment activities for MG Set 3A. If the MG set rotor assembly was not oriented properly prior to a lift (bus bars not on top), the bus bars could experience the weight of the rotor via lifting straps. Activities which require lifting the MG set rotor assembly occur only during major maintenance and are infrequent. Also, though considered unlikely, it is possible the

bars were bent during original factory fabrication of the affected MG set.

IV. ANALYSIS OF THE EVENT

Plant safety systems and associated components performed as designed. The event is categorized as a recirculation pump trip and is an analyzed plant transient. Therefore, the event did not affect the health or safety of the public.

V. CORRECTIVE ACTIONS

A. Immediate Corrective Actions:

Both bus bars on MG 3A set and the generator collector rings were replaced. Associated circuit components were tested to verify no damage had occurred due to the failure transient. MG Set 3A and Reactor Recirculation Pump 3A were successfully returned to service on September 17, 1996, and Unit 3 restarted directly afterwards.

B. Corrective Actions to Prevent Recurrence:

The bus bars on the Unit 1 MG sets were visually inspected and no pronounced bending was present. For the MG sets that were operating, (Unit 2 MG sets and MG Set 3B) a stroboscope inspection was performed with no pronounced bends observed. Also, a thermography scan was made on the operating MG sets to detect potential hot spots that might result from a cracked

bar. None were observed.

Bus bars from MG Set 1A were used to replace the damaged Unit 3 bus bars. No cracks were seen in the Unit 1 bus bars. The remaining bars are insulated and can not be inspected without removing the insulation. However, since the remaining MG sets did not have pronounced bends in the bus bars, it is unlikely that these bars are cracked and thus susceptible to a similar failure.

In addition, the problem report associated with this event will be reviewed by maintenance personel as experience information. 1_/

_____

1_/ This action is being tracked by TVA's Corrective Action Program and is not considered a regulatory commitment.

VI. ADDITIONAL INFORMATION

A. Failed Components:

Solid copper bus bars in the armature circuit on a reactor recirculation pump MG set. The MG set was manufactured by General Electric Corporation.

B. Previous LERs on Similar Events:

No previous BFN events were identified involving the trip of a recirculation system MG set due to a failure of bus bars. A

search of industry operating experience databases also found no

similar failures.

VII. COMMITMENTS

None.

Energy Industry Identification System (EIIS) system and component codes

are identified in the text with brackets (e.g., [XX]).

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TVA

Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609-

2000

R. D. (Rick) Machon

Vice President, Browns Ferry Nuclear Plant

October 15, 1996

U.S. Nuclear Regulatory Commission 10 CFR 50.73

ATTN: Document Control Desk

Washington, D.C. 20555

Dear Sir:

BROWNS FERRY NUCLEAR PLANT (BFN) - UNIT 3 - DOCKET NO. 50-296 - FACILITY

OPERATING LICENSE DPR-68 - LICENSEE EVENT REPORT 50-296/96005

The enclosed report provides details concerning the completion of a

manual reactor shutdown required by Technical specifications following

the trip of Reactor Recirculation Motor Generator Set 3A and

consequently, Reactor Recirculation Pump 3A. BFN Technical Specifications require that the reactor be shutdown within 24 hours if operating with a single recirculation pump in service. Therefore, reactor power was subsequently reduced and the reactor manually scrammed. This report is submitted in accordance with 10 CFR 50.73 (a)(2)(I)(A) as a completion of a plant shutdown required by plant Technical Specifications.

Sincerely,

R. D. Machon

cc: See page 2

Enclosure

cc (Enclosure):

Mr. Mark S. Lesser, Branch Chief

U.S. Nuclear Regulatory Commission

Region II

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